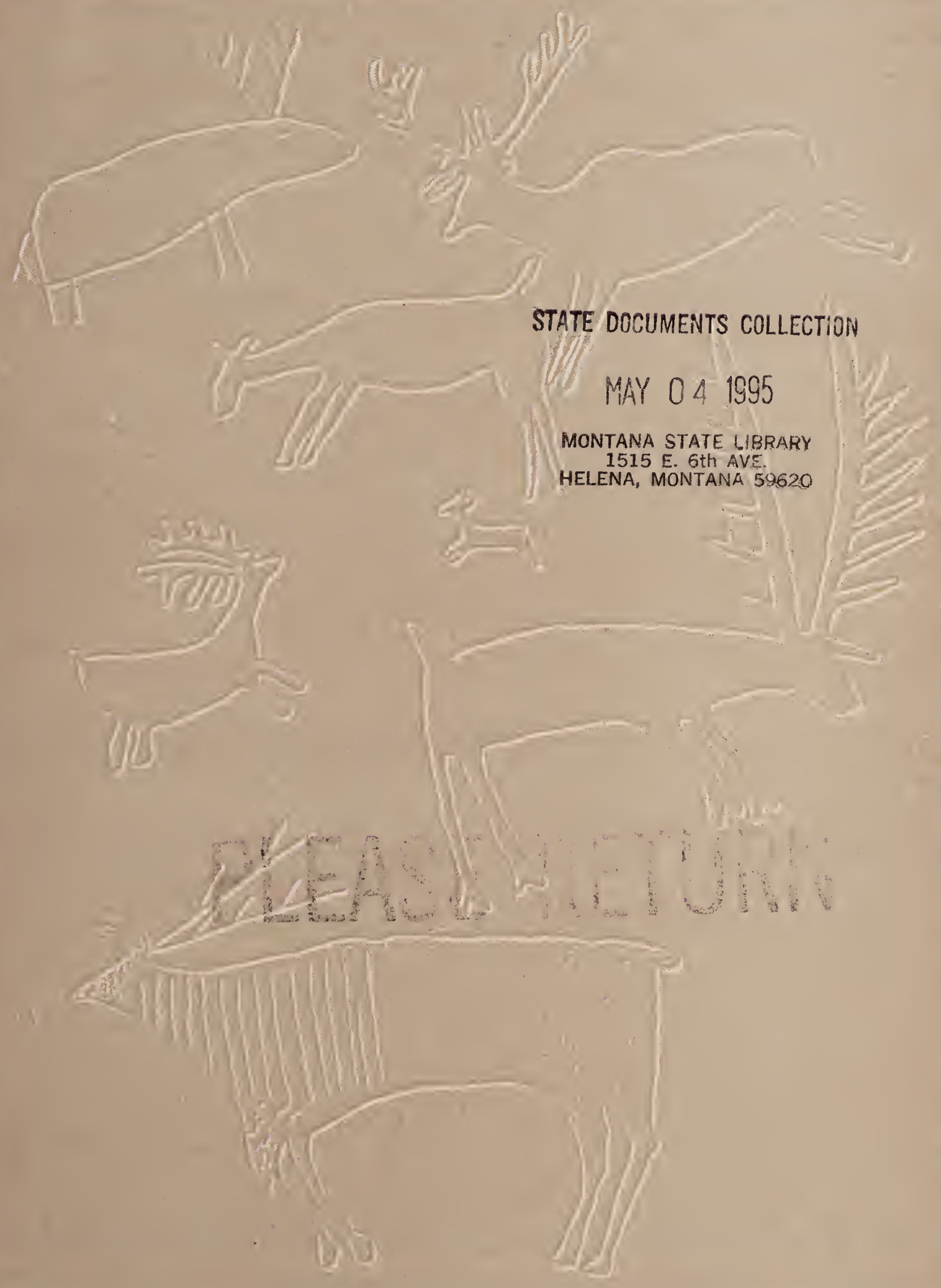
S
799.7357
F2edp
1994

Elk population
dynamics and breeding
biology, Gravelly -
Snowcrest Mountains
progress report.

vcrest Mountains

ELK POPULATION DYNAMICS and BREEDING BIOLOGY



STATE DOCUMENTS COLLECTION
MAY 04 1995
MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

PLEASE RETURN

Montana Department of
Fish, Wildlife & Parks

1994 PROGRESS REPORT

MONTANA STATE LIBRARY
3 0864 0010 2149 5

JOB PROGRESS REPORT

RESEARCH PROJECT

STATE:	Montana		
PROGRAM NO:	W-100-R-2	TITLE:	Wildlife Program
ELEMENT NO:	I	TITLE:	Wildlife Management in Montana by Ecoregion
PROJECT NO:	2	TITLE:	Wildlife Management in the Southwest Montane Ecoregion
OBJECTIVE:	5	TITLE:	Gravelly-Snowcrest Mountains Elk Study
JOB NO:	1	TITLE:	Elk Study Planning and Coordination

Period Covered: July 1, 1993 - June 30, 1994

Prepared by: Kenneth L Hamlin
Kenneth L. Hamlin

Michael S. Ross
Michael S. Ross

Approved by: Terry N. Lonner
Joel G. Peterson

Date: December 31, 1994

Since this is a Progress Report only, results presented herein are not necessarily final and may be subject to change. For this reason, the information contained in this report may not be published or used for other purposes without permission of the Director.

Digitized by the Internet Archive
in 2018 with funding from
Montana State Library

https://archive.org/details/elkpopulationdyn1994mont

OBJECTIVE

Assist with the compilation and evaluation of existing databases on several elk herds in Montana. Coordinate and recommend research, management studies, and procedures which will provide for more effective management and a better understanding of elk population dynamics.

METHODS

Published and unpublished data continued to be compiled and evaluated. Meetings with MDFWP biologists, wildlife managers, and planners were continued to obtain their viewpoints and knowledge. This information will continue to be synthesized with the aid of the computer programs SAS, Dbase, POSIM (Mooney and Lonner 1978), and TELDAY (Wildlife Div. MDFWP 1986) to better organize existing databases and evaluate elk management in Montana.

RESULTS AND DISCUSSION

Coordination with Montana Department of Fish, Wildlife and Parks' biologists and game managers was continued to address future management and research needs for elk. Response was given to a variety of requests for information and/or advice on elk management and research. Known-age elk jaws for check station aging boards were provided for several people.

Some time during the report period was spent writing sections of the elk chapter of the State Programmatic Environmental Impact Statement and coordinating with other writers on the chapter. The first draft of the chapter was completed during the period.

A meeting of Montana and Idaho personnel about management of border area wildlife, including elk, was attended. A meeting with USFS biologists was attended to draw up suggestions for amendments to east side Forest Plans related to elk vulnerability. A presentation on study results was made to the Montana Dept. Fish, Wildlife and Parks commissioners. Several Project Wild meetings were attended and information provided at other times to help complete an educators' guide to elk. Substantial amounts of time were spent providing information and consultation to reporters, school classes and individuals, and state and federal biologists and administrators.

RECOMMENDATIONS

This aspect of the overall study should be continued in accordance with the objectives and methods stated in the Application for Federal Aid for this research effort.

LITERATURE CITED

Mooney, E. L., and T. N. Lonner. 1978. POSIM-1 General Wildlife Population Simulator. Pps. 631-640. In H. J. Higland, N. R. Neilson and L. G. Hulls Eds. Proc. 1978 Winter Simulation Conf., Miami, FL., Dec. 4-6, 1978. 1,051 pp.

SAS Institute, Inc. 1985. SAS user's guide: statistics. Version 5 ed. SAS Inst., Inc., Cary, NC. 956 pp.

Wildlife Division. 1986. TELDAY user's manual. Montana Department of Fish, Wildlife and Parks, Helena. In Revision.

JOB PROGRESS REPORT

RESEARCH PROJECT

STATE:	Montana		
PROGRAM:	W-100-R-2	TITLE:	Wildlife Program
ELEMENT NO:	I	TITLE:	Wildlife Management in Montana by Ecoregion
PROJECT NO:	2	TITLE:	Wildlife Management in the Southwest Montane Ecoregion
OBJECTIVE:	5	TITLE:	Gravelly-Snowcrest Mountains Elk Study
JOB NO:	2	TITLE:	Elk Population Dynamics and Breeding Biology

Period Covered: July 1, 1993 - June 30, 1994

Prepared by: Kenneth L Hamlin
Kenneth L. Hamlin

Approved by: Terry N. Lonner
Joel G. Peterson

Michael S. Ross
Michael S. Ross

Date: December 31, 1994

Since this is a Progress Report only, results presented herein are not necessarily final and may be subject to change. For this reason, the information contained in this report may not be published or used for other purposes without permission of the Director.

INTRODUCTION

Elk (*Cervus elaphus nelsoni*) management in Montana during the 1980s was primarily directed toward increasing elk numbers and maintaining a diversity of choice in elk hunting opportunity. In earlier years, diversity of choice was maintained by either-sex elk hunting. In 1963, 67% of Montana's hunted elk habitat was open to season-long either-sex hunting. More recently, season-long either-sex hunting has declined (to 1% of elk habitat by 1985) and diversity of choice has been maintained by a diversity of regulations among hunting units (Wildlife Division, MDFWP, 1985). Also, managing elk populations within the bounds of landowner tolerance has received greater emphasis.

The any antlered bull regulation remained widespread, but an increasing number of hunting units were restricted to branch-antlered bull hunting. In 1981, only one hunting district (HD 324) was restricted to branch-antlered bull harvest. By 1985, seven hunting districts had branch-antlered bull regulations and two were branch-antlered bull after an either-sex quota was reached. In 1989, 28 hunting districts and portions of 2 others had branch-antlered bull regulations.

Depending on the area, the branch-antlered bull regulation resulted from concerns over low calf/cow ratios and the long-term biological effects of yearling bulls siring most of the calves or from some hunters wanting to harvest a larger bull. The MDFWP cautioned hunters that few bulls older than 2 and one half years of age would be harvested following implementation of this regulation.

Low observed calf:cow ratios in the Gravelly-Snowcrest Mountains during the winters of 1979-80 and 1980-81 (18-35 calves:100 cows versus 55-68:100 during 1970-75, Chrest and Herbert 1980 and 1981), coincided with low antlered bull:cow ratios. Available evidence suggested that low proportions of mature bulls in elk populations might negatively affect calf production and/or survival and population size (Hines and Lemos 1979, Prothero et al. 1979, and Smith 1980). Concern over the observed low calf:cow and bull:cow ratios resulted in changes in hunting regulations in HD 324 during 1981. The early archery season was eliminated, and the kill during the general elk season was limited to branch-antlered bulls. The branch-antlered bull regulation was also implemented in HDs 323, 326, and 330 during 1983 and HD 325 and the northern portion of HD 327 during 1987. The early archery season was restored in HD 324 during 1988.

In 1990, a brow-tined bull regulation was implemented in areas that previously had a branch-antlered bull regulation. Thirty hunting units had brow-tined bull regulations in 1990 and 38 in 1992. This regulation is an attempt to reduce the degree of illegal mortality of yearling or "spike" bulls experienced under branch-antlered bull management (Hamlin and Ross 1990b, DeSimone and Vore 1992).

This study was initiated in January 1984 to assess the role and importance of various hunting strategies on elk population characteristics and dynamics. Emphasis has been directed toward breeding biology, reproductive success, calf recruitment, seasonal distribution, movements, and habitat use. Effect of various hunting strategies on hunter success, attitudes, and other factors was also evaluated.

OBJECTIVES

1. Determine the effects of alternate hunting regulations and harvest rates on elk population dynamics and habitat use.

2. Test the hypothesis that when mature bulls (2+ years) comprise less than 5% of an elk population during the breeding season, the net reproductive success will be less than when compared to when the population has greater than 5% mature bulls.

3. Assist biologists with evaluation of existing elk population data and utilize the results from this study to better understand elk population dynamics and manage harvests.

STUDY AREA

Because of low observed calf:cow and bull:cow ratios, the popularity of the area for hunting, and the changes in hunting regulations already in place, the Gravelly-Snowcrest Mountains in southwestern Montana were selected as the primary study area. In 1984 and 1985, work was concentrated on elk that winter on the Madison-Wall Creek Wildlife Management Area (WCWMA) south of Ennis. Elk that winter in the Cherry-Morgan area just north of Wall Creek were also captured and marked. The physiography and vegetation of this area have been described by Eustace (1967) and Gniadek (1987).

In 1986, work was expanded to include elk that wintered on the Blacktail Wildlife Management Area (BTWMA) southeast of Dillon. In spring 1989, the study area was expanded by marking elk that winter on the Robb-Ledford area, the Warmsprings area, and the Basin-Sage Creek area (Hamlin and Ross 1990a). During this report period, elk were captured and marked in the Sweetwater Hills and the Greenhorn Mountains, two previously unsampled wintering areas. The expanded study primarily involves current MDFWP hunting districts 323, 324, 325, 326, 327, and 330 (Fig. 1).

METHODS

Methods employed were similar to those reported previously (Lonner and Schladweiler 1987, Hamlin and Ross 1990b).

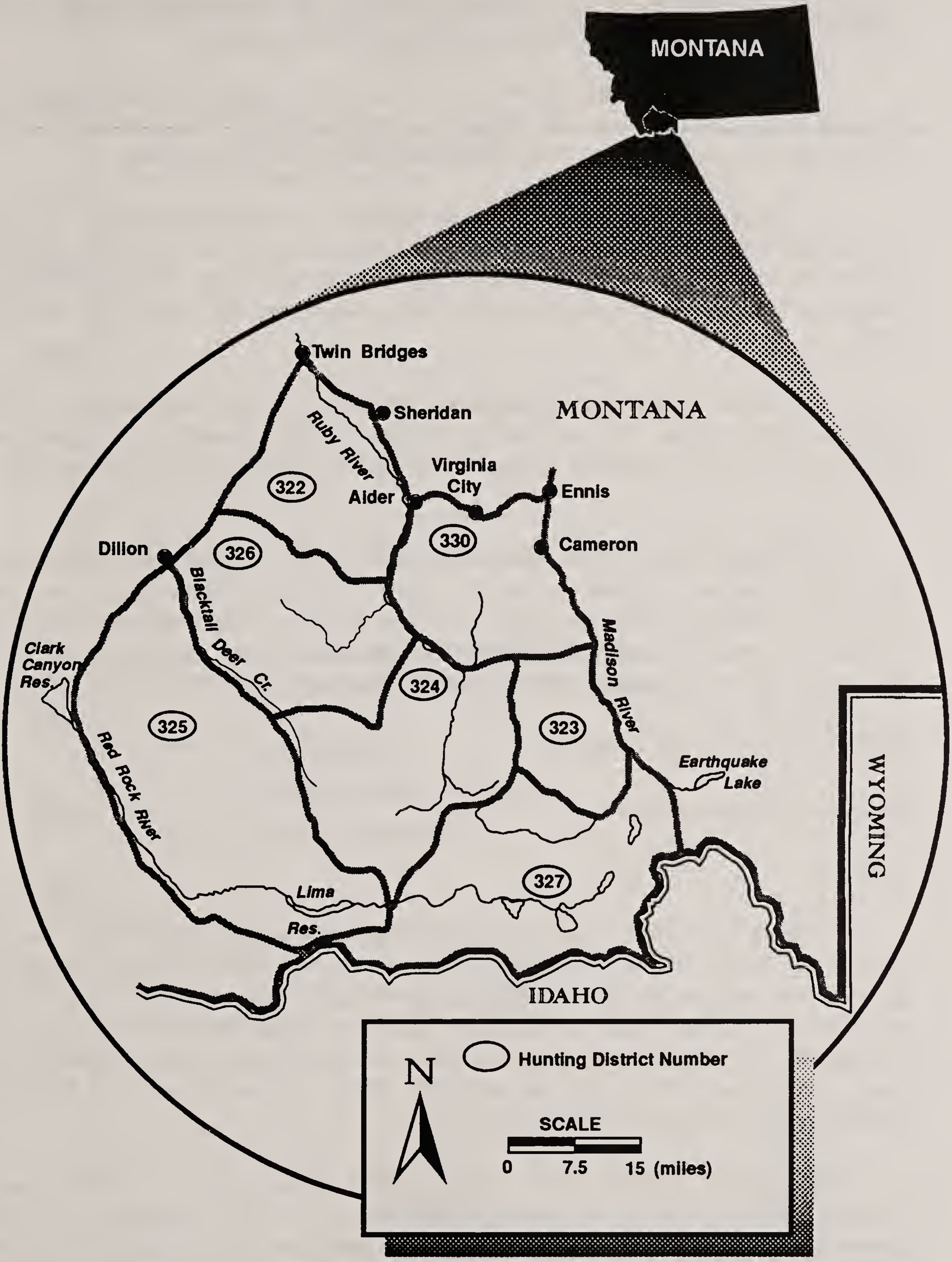


Figure 1. Location of hunting districts within the Gravelly-Snowcrest study area.

During March 1994, capture of 56 elk was accomplished by helicopter netgunning.

Radio-transmitter collars and eartags were placed on all 36 male calves, 10 adult females, and 3 adult males. Neckbands and eartags only were placed on five female calves and one adult female. One female calf was released unmarked.

To help establish herd range on unsampled or undersampled areas, we captured and marked three adult females on Blacktail Ridge, three in the Greenhorn Mountains, two in the Sweetwater Hills, and two in the Warmsprings area. We also captured and marked a two-year-old, a three-year-old, and a four-year-old bull on the Wall Creek WMA.

An incisor was collected from each elk older than two years during 1992-93 at check stations or from other mortalities. Age was assigned based on cementum analysis (Gilbert 1966) and compared to ages assigned by eruption-wear (Quimby and Gaab 1957).

As in prior years, blood samples collected from captured elk were measured at the MSU Veterinary Research Lab for blood chemistry, whole blood, and disease parameters. Blood samples for 1992, 1993, and 1994 were analyzed by R. Garth Sasser of the University of Idaho Animal and Veterinary Science Department for level of pregnancy-specific protein B (PSPB) to determine pregnancy (Wood et al. 1986).

RESULTS AND DISCUSSION

Population Characteristics

Numbers

Trends in numbers of elk observed during aerial surveys from 1947 to the present in the WCWMA vicinity and from 1948 in the BTWMA vicinity indicated that populations stabilized or declined slightly between 1992-93 and 1993-94 (Fig. 2). Total numbers of elk observed for the Gravelly-Snowcrest Range declined (Table 1). We do not believe the population declined but that counting conditions were worse than other years, similar to 1990-91 (Hamlin and Ross 1991). Some elk were far from normal winter ranges at the time of the survey.

Population estimates made using hunting mortality rate of radio-transmitter collared elk and classification ratios (Hamlin and Ross 1990b) indicated a post-season population of 14,110 elk for the Gravelly-Snowcrest complex during 1993-94. Only 5 (0.082) of 61 adult cows with functioning radio-transmitter collars were harvested and retrieved during fall 1993. We believe the population estimate of 14,110 is too high, but the total count of 6,134 is a lower than normal trend estimate. Harvest information and

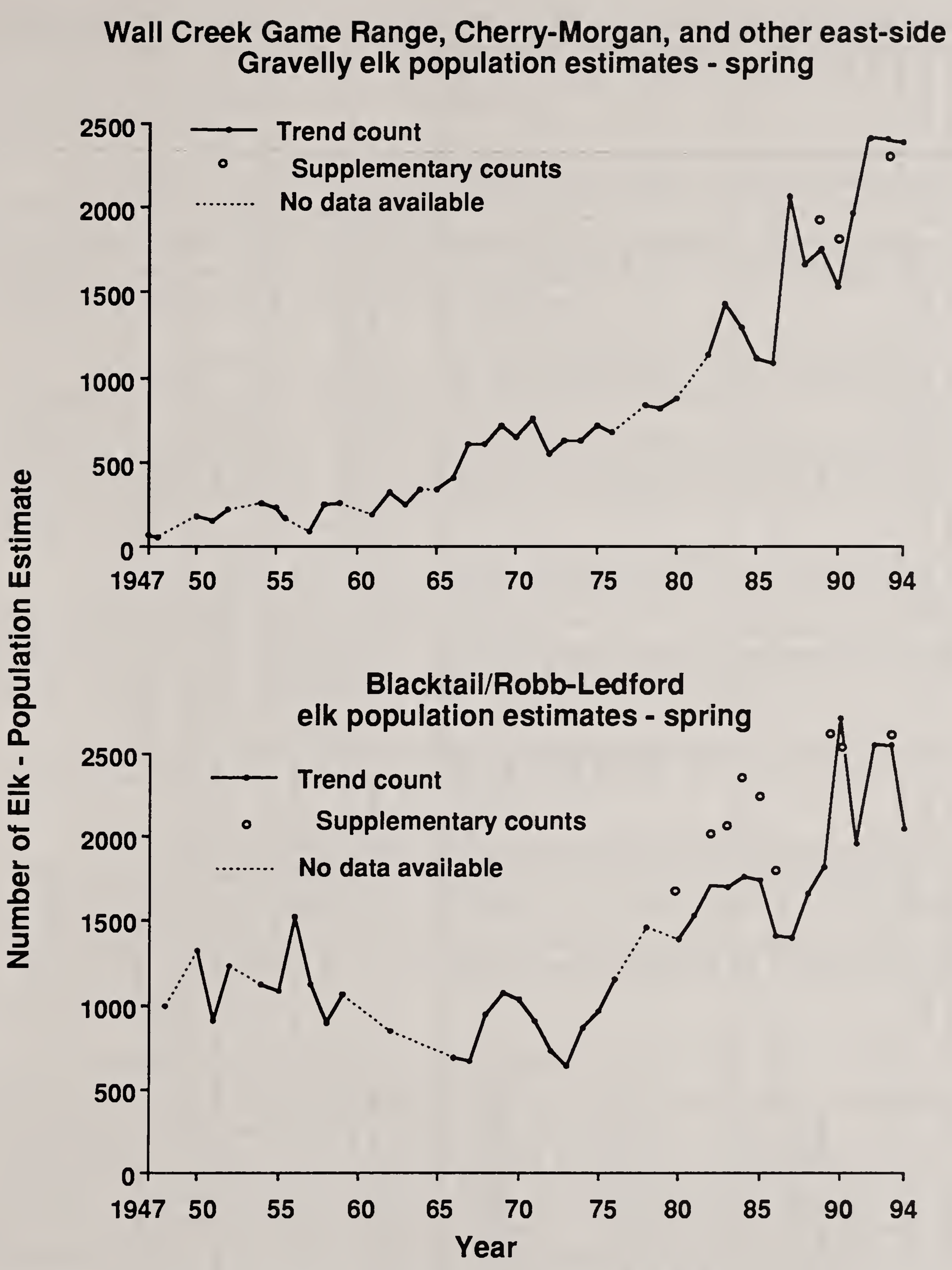


Figure 2. Trends in numbers of elk observed during winter aerial surveys of the east side of the Gravellys area and the Blacktail-Robb-Ledford Wildlife Management Areas, 1947-1994.

Table 1. General locations of elk observations and counts for the winters of 1984-85 through 1992-94.

	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91[b]	1991-92	1992-93	1993-94
Axolotl Lake Area	33	97	80	14	0	0	114	218	226	194
Cherry-Morgan Creeks Area	414	150	623	233	260	512	444	791	717	529
Madison-Wall Creek Game Range	664	805	1,233	1,182	1,401	880	1,249	1,373[c]	1,343	1,591
Missouri Flats-West Fork Madison	---[a]	35	134	132	91	157	162	32	123	77[h]
Total for east side of Gravellys	1,111	1,087	2,070	1,661	1,752	1,549	1,969	2,414[c]	2,409	2,391
North Centennial Valley	57	19	62	57	0	0	0	0	0	0
South Centennial Valley	--[a]	---[a]	---[a]	---[a]	---[a]	310	93	71	27	401[i]
Blacktail & Robb-Ledford	1,740	1,416	1,403	1,663	1,820	2,719	1,918	2,517[d]	2,510	2,045
Greenhorn Mtns. & Lower Ruby River	---[a]	323	432	463	317	458	418	514	512	276
Little Sage-Basin Creeks Area	---[a]	199	365	322	490	537	442	840[e]	756	546
Blacktail Ridge	---[a]	---[a]	189	273	425	493	284	815[f]	933	359
Sweetwater Hills	---	---	---	---	---	---	---	145	98	116
Total Blacktail-Centennial-Greenhorns	1,797	1,957	2,451	2,778	3,052	4,517	3,155	4,902[def]	4,836	3,743
Grand Total	2,908	3,044	4,521	4,439	4,804	6,066	5,124[b]	7,316[g]	7,245	6,134[b]

[a] No flights were made over these areas.

[b] Because of wide dispersal during winter 1990-91 and 1993-94, a greater than usual portion of the elk were missed during aerial counts.

[c] A group of 477 elk counted near Wall Canyon are not included because we believe they were elk normally on the Sun Ranch, east of the Madison River. An ongoing late-season hunt is believed to have pushed them across to the Gravellys.

[d] This total includes 319 elk believed missed during the first flight and observed on a second flight.

[e] We counted 968 elk here on 12-20-91 with none observed in the Centennial at that time. Some of these elk may have moved back to Corral Creek in the Centennial and Price Canyon on Blacktail Ridge by 01-18-92.

[f] Of these, 109 observed in Price Canyon may be Basin-Sage Creek elk based on a neckband observed in the group.

[g] Depending upon the status of possible missed groups and extra Sun Ranch elk above, the total count could range from 6,997 to 7,793.

[h] On 03-20-94, Craig Fager counted 223 elk here.

[i] 77 of these were in Idaho; these elk are usually in Basin-Sage Cr. & Blacktail Ridge during "normal" winters.

other mortality data along with calf production data indicate that the population should have been stable to increasing compared to previous years.

Sex and Age Structure

Classifications - Sex and age classifications made from the ground (Table 2, Fig. 3) indicated little change in calf production/survival from 1992-93. Total bulls:100 cows were higher on the WCWMA and at Robb-Ledford, but lower on the BTWMA. Because smaller samples than usual were collected, we believe the ratio for WCWMA is higher and that for the BTWMA is lower than the true ratio.

Aerial classifications (Table 3, Fig. 3) indicated fewer total bulls than 1992-93, but more bulls $\geq$ 2 years. We believe that because of counting conditions, both total bulls and bulls $\geq$ 2 years are underrepresented by these data. Similarly, only minimum figures are listed for bulls $\geq$ 3 years old in Table 3. Even if minimal, these data do indicate increased survival of 2-year-old bulls. The increased number of bulls should be evident in 1994 harvest age structure.

Fewer yearling males were classified for antler branching than in previous years. Of a total 63 yearlings classified from the ground and aerially, including illegally killed yearlings, 12 (19.1%) were branched. One of four radio-collared yearlings had branched antlers. Both of these percentages are higher than in previous years.

Capture and Harvest - Age structure of harvested females continued to reconcile well with previous spring calf:100 cow classifications (Table 4).

As in all previous years, reported sex ratio of calves in the harvest (29 males:40 females) favored females (Table 5). Calf sex ratios in both harvest and helicopter drive-netting have consistently indicated more females than males (Hamlin and Ross 1990b). We have not determined if these sex ratios accurately represent the population. If accurate, they may explain some of the yearling males believed to be "missing" (Hamlin and Ross 1990b).

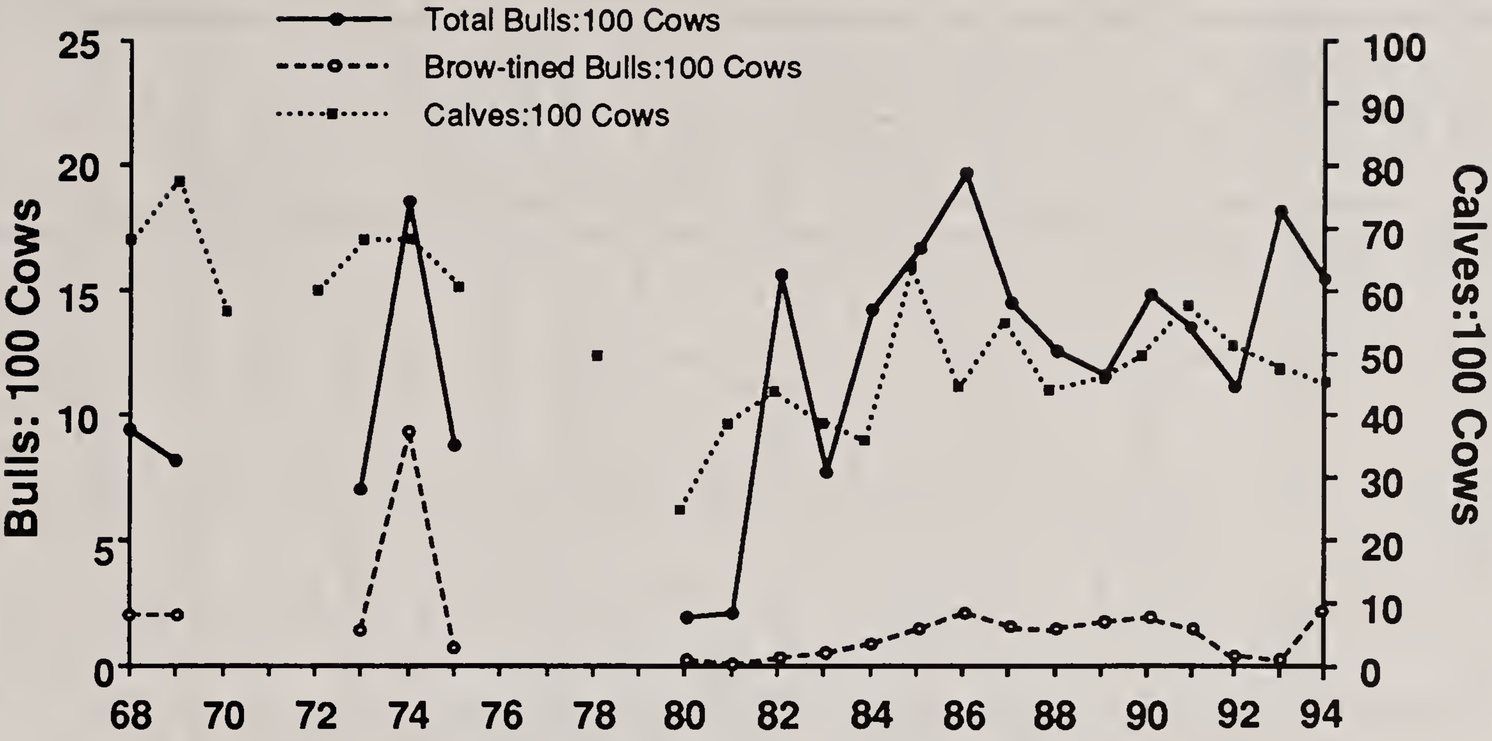
The results for helicopter net-gun capture of calves last year (34 males:21 females, Hamlin and Ross 1993) were different than usual ratios obtained for helicopter drive-netting. Tests of selective abilities of the helicopter net-gunners were again conducted during March 1994. We attempted to capture mostly male calves and were successful (36 males and 6 females). Overall, 161 males and 220 females (0.73:1.00) were captured by drive-netting, and 70 males and 27 females (2.59:1.00) were captured by net-gunning. A valid sex-selection technique appears to be established for 8-9 month old elk calves to be captured by helicopter net-gun. Male calves usually have a light yellowish-white rump patch, and the rump patch of female calves is usually a darker "orange" color. This difference may not be as apparent for calves younger than 8-9 months old.

Table 2. Classification results from ground observations in the Gravelly-Snowcrest Mountains, winter-spring 1994.

Area	Wall Creek WMA	Blacktail WMA	Robb-Ledford[a]
Date	February 28, 1994	March 15 & 16, 1994	March 1, 1994
Total	759	623	327
Cows	408	394	191
Calves	204	180	98
Bulls	147	49	38
Yearling 1X1	(22)	(6)	--
Yearling 1X2+	(5)	(2)	--
Raghorn Bulls	21	0	--
3+ Bulls	11	-	--
Uncl. Ylg. Bulls	115	49	38
Calves:100 cows	50.0	45.7	51.3
% Bulls	19.4	7.9	11.6
Bulls:100 cows	36.0	12.4	19.9
% BA Yearlings	18.5	25.0	--

[a] Classification by Bob Brannon

A. Blacktail Wildlife Management Area



B. Wall Creek Wildlife Management Area

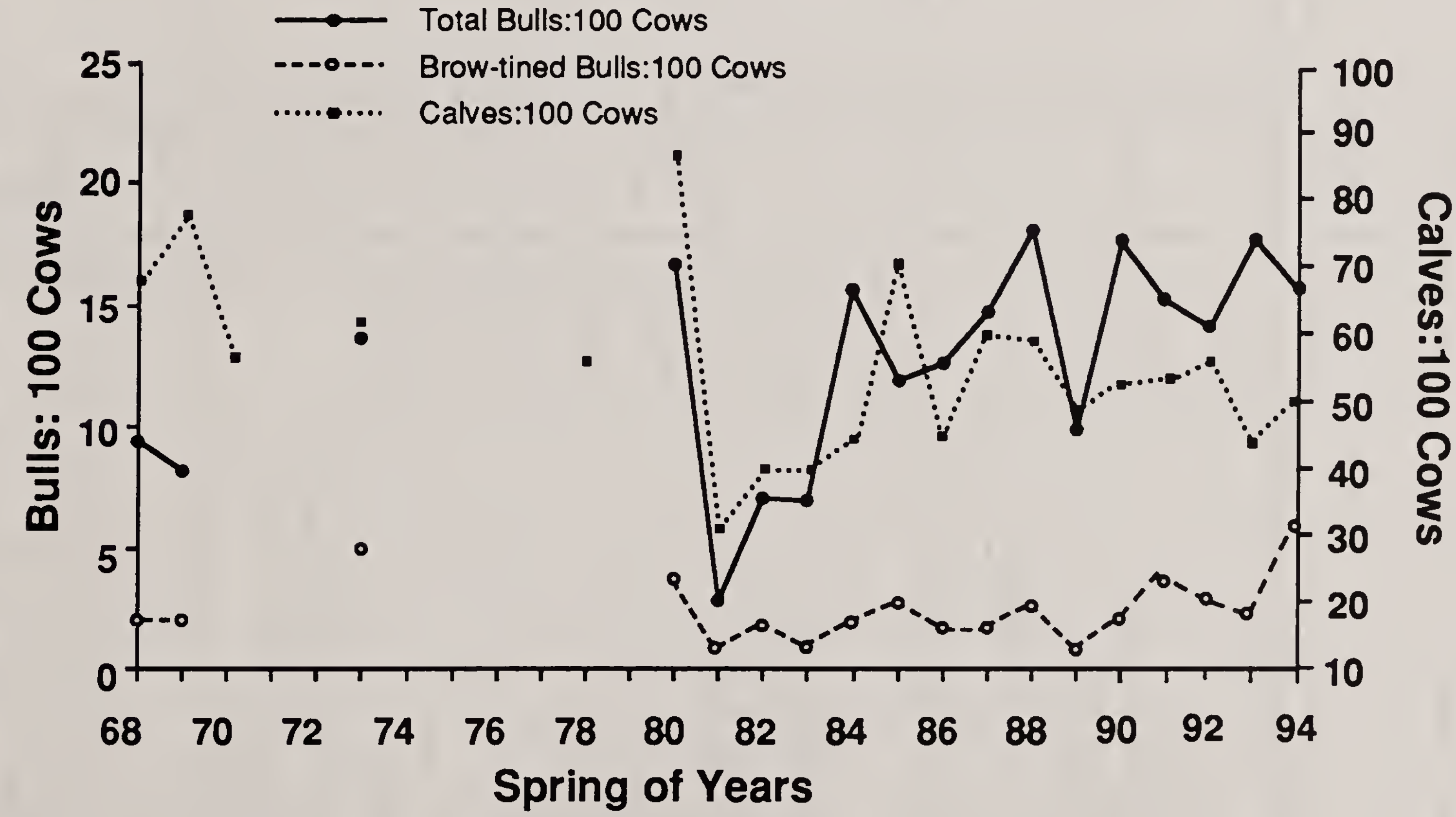


Figure 3. Sex and age structure of elk populations on the (A) Blacktail Wildlife Management Area and (B) Wall Creek Wildlife Management Area during spring, 1968-1994.

Table 3. Aerial counts and classifications for the Gravelly-Snowcrest elk herds, winter 1994.

Area	Date	Total Elk	Total Males	Total Class. Males[a]	Total Yearling Males	Spikes	≥ 1x2 Ylgs.	Raghorns	Bulls ≥ 3 Years
Axolotl area	03-07-94	194	10	10	7	--	--	2	1
Cherry-Morgan area	03-07-94	529	27	27	25	--	--	2	--
Wall Cr. WMA vicinity	03-07-94	1,591	152	145	88	--	--	54	3
Sheep Cr. - West Fork Madison vic.	03-07-94	77	6	6	0	0	0	6	0
TOTAL - EAST SIDE GRAVELLYS		2,391	195	188	120	--	--	64	4
Greenhorns	03-07-94	127	44	44	34	--	--	5	5
Warmsprings - Ruby area	03-07-94	149	1	1	1	1	0	0	0
Robb-Ledford WMA vic.	03-08-94	104	16	16	11	--	--	3	2
Blacktail WMA vic.	03-08-94	1,941	183	183	155	--	--	28	--
Sweetwater Hills	03-08-94	116	23	23	23	--	--	0	0
Blacktail Ridge	03-07-94	359	59	59	47	--	--	12	0
Basin-Sage Cr.	03-07-94	546	73	73	59	--	--	14	0
South Centennial	03-07-94	401	--	--	--	--	--	--	--
TOTAL WEST SIDE GRAVELLYS, SNOWCRESTS, BT RIDGE, BASIN-SAGE, CENTENNIAL		3,743 (3,342)[b]	399	399	330	--	--	62	7
GRAND TOTAL		6,134 (5,733)[b]	594	587	450	--	--	126	11

[a] unclassified males are yearlings but unclassified to branching

[b] total classified

Table 4. Estimated percent yearling cows in autumn populations based on spring classifications and estimated calf:100 cow ratios the previous spring based on age structure of the female harvest, 1984-93.

	Calves:100 cows Spring classification	Estimated % yearling cows in autumn population based on spring classifications[a]	Estimated % yearling cows in autumn population based on age structure of hunter harvest	Estimated calves:100 cows previous spring based on harvest age structure
1984	38	16.0	17.7	43
1985	66	24.8	15.1	36
1986	42	17.4	18.8	46
1987	56	22.0	21.4	54
1988	50	19.9	22.8	59
1989	45	18.8	19.1	47
1990	49	19.7	21.7	55
1991	53	21.0	18.5	45
1992	54	21.3	21.4	54
1993	45	18.5	17.2	42

[a] The projected % yearlings in the autumn population based on spring calf:100 cow ratios is calculated in the following way:

spring 1984:	38 calves:100 cows = 19 female calves:100 cows
summer-autumn 1984:	19 yearling cows/119 total cows = 0.1597

The percentage of yearling females in the autumn 1993 harvest (Table 5) declined from autumn 1992 reflecting lower calf production/survival in 1992-93 (Table 4). The percentage of males in the harvest older than 2 years declined (Table 5). Two-year-old males comprised 92.5% of the bull harvest. The average age of bulls $\geq$ 2 years olds was the lowest since the study began (Fig. 4).

Table 5. Sex and age structure of elk checked at hunter check stations and of jaws left in jaw barrels during 1993.

Age	Females		Males	
½	40[a]		29	
1½	45	(17.2)[b]	--	
2½	43	(16.4)	98	(92.5)
3½	42	(16.0)	6	(5.7)
4½	30	(11.5)	2	(1.9)
5½	32	(12.2)		
6½	18	(6.9)		
7½	10	(3.8)		
8½	11	(4.2)		
9½	5	(1.9)		
10½	10	(3.8)		
11½	2	(0.8)		
12½	4	(1.5)		
13½	1	(0.4)		
14½	2	(0.8)		
15½	3	(1.2)		
16½	3	(1.2)		
17½	0	(0)		
18½	0	(0)		
19½	1	(0.4)		
20½	0	(0)		
21½	0	(0)		
unk. 1+	7			
unk. 2+	--		5	
No. 1½+	262 + 7		106 + 5	

[a] number

[b] number (%) of aged 1½+ year-olds

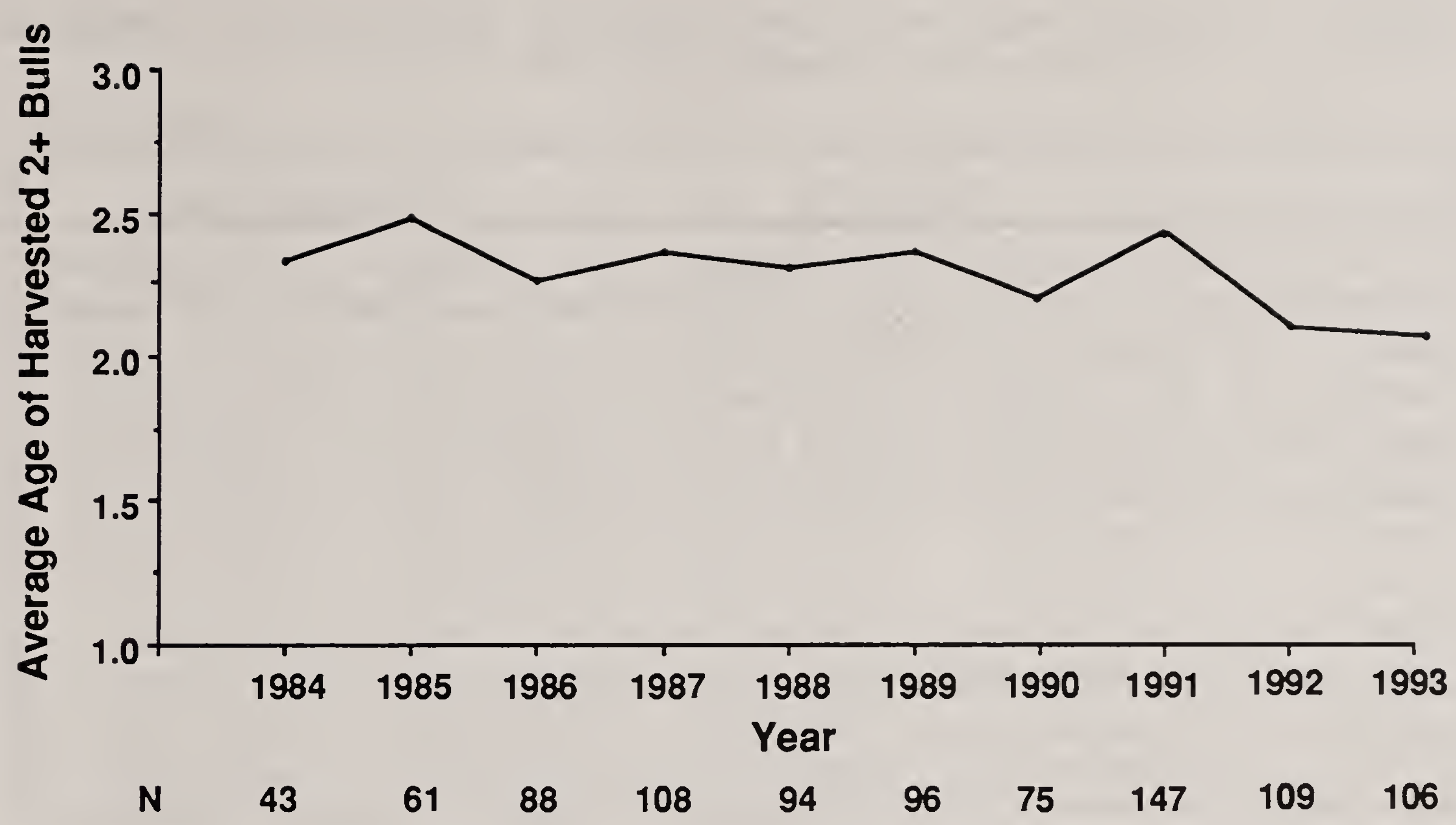


Figure 4. Average age of bulls ≥ 2 years old harvested in Gravelly-Snowcrest hunting districts, 1984-1993.

Condition Parameters

Weight and Diastema

Field dressed weights of hunter-harvested calves were the second highest recorded for males and third highest for females (Table 6). Diastema length was greater than in 1992 for both males and females, but was not near all time highs as occurred for weight. Heart-girth measurements (in.) of captured calves (Males - $\bar{X}$ = 53.9, N = 34; Females $\bar{X}$ = 52.9, N = 5) were much larger than in previous years (Males - $\bar{X}$ = 49.4-51.6; Females - $\bar{X}$ = 48.5-50.6, Hamlin and Ross 1992). In combination, these data indicate that elk calves were in better condition than average during 1993-94.

Blood Chemistry and Hematology

Data were summarized through 1991 (Hamlin and Ross 1991) but will not be analyzed further until the last capture operations are completed in spring 1995.

Disease and Parasites

All 50 blood samples collected in 1994 were negative for brucellosis, blue tongue, and anaplasmosis. A total of four (8.0%) of 50 elk were positive reactors for leptospirosis serovar tarassovi. One was also positive for serovar autumnalis.

Table 6. Average weight and diastema length for hunter-killed elk calves in the Gravelly-Snowcrest Mountains, 1984-1993.

	Weight (lbs)		Diastema (mm)	
	Male	Female	Male	Female
1984	200.2 (5)[a]	159.1 (9)[a]	83.7 (6)[b]	79.1 (14)[b]
1985	178.0 (4)	178.7 (6)	81.8 (20)	81.7 (34)
1986	179.0 (8)	156.7 (9)	82.2 (16)	80.5 (35)
1987	172.5 (2)	150.7 (7)	82.1 (21)	84.2 (32)
1988	166.8 (9)	152.2 (10)	85.9 (9)	82.3 (21)
1989	160.8 (9)	146.8 (10)	81.1 (24)	81.7 (26)
1990	183.8 (4)	164.8 (10)	85.8 (8)	85.8 (16)
1991	163.5 (10)	153.7 (14)	83.2 (32)	82.7 (45)
1992	164.0 (11)	152.0 (8)	81.8 (21)	80.6 (25)
1993	198.8 (5)	160.6 (10)	83.6 (23)	81.7 (36)

[a] weight in lbs (sample size)
[b] diastema in mm (sample size)

Fecal samples were collected from 49 of the elk captured in March 1994. These samples were analyzed by the MDFWP Wildlife Laboratory with standard Baerman and fecal flotation techniques. Lungworms were found in 21 (42.9%) of the samples. Lungworms per gram ranged from 1 to 27; three were above 5. Trichuris and Haemonchus ova were detected in one sample each. The overall parasite load based on this one fecal sample indicated a low prevalence and the prevalence and intensity of lungworm infection was low to moderate (K. Aune, pers. comm.).

Reproduction

Twenty-one blood samples from 1992-1994 were tested for pregnancy using level of pregnancy-specific protein B (Wood et al. 1986) and six reproductive tracts were also examined. For all determinations of pregnancy made during 1984-1994, 31 (35.6%) of 87 yearlings were pregnant, 39 (92.9%) of 42 2-year-olds were pregnant, 142 (96.0%) of 148 3-5 year olds were pregnant, 54 (93.1%) of 58 6-8 year olds were pregnant, and 13 (92.9%) of 14 females $\geq$ 9 years old were pregnant. For all females $\geq$ 2 years old, 248 (94.7%) of 262 were pregnant. Based on these average pregnancy rates and information on calf production (Table 2) and age structure (Table 5), population calf:100 cow ratio at birth in June 1994 is estimated to have been 68 calves:100 cows.

Mortality

Adult Females

Annual mortality rate for the sample of adult females with functioning radio-transmitter collars was 9.8% (Table 7), the lowest since widespread samples were accomplished in 1986-87. All mortality in this sample was attributable to hunting including one crippling loss. Check station data indicated 16.4% less antlerless harvest in 1993 than 1992, and statewide telephone harvest survey data indicated 9.8% less antlerless harvest. This information indicated that aerial trend counts probably missed more elk than usual in 1994. With the low observed mortality, trend counts should have been at least stable to above those of 1993.

A minimum of 91% of the annual mortality of adult females has been hunting related during 1984-1993. Crippling loss has averaged 15% of retrieved, reported legal kill and 13.9% of all retrieved kill. This is also an annual rate of 1.5% for the adult female population. One recently captured female, not part of the annual sample, died after becoming stuck in a mudhole during spring 1994.

Adult Males

Of 27 radio-transmitter collared yearling males that were accounted for prior to the 1993 BTB season, 23 (85.2%) survived. Four (14.8%) were illegally killed.

Of 26 bulls $\geq$ 2 years old accounted for prior to the 1993 BTB season, 11 (42.3%) survived. Thirteen (50%) were known mortalities. Eleven were shot and reported, one was shot in Idaho and not reported, and one was shot in Idaho and not retrieved. Radio contact with one bull was lost during the last week of the season. The collar broke and was shed by another bull during the last week of the season. Collar breakage on this bull appeared to be caused by puncture from an antler of another bull. This minimum survival of 42.3% of bulls $\geq$ 2 years old was the highest recorded during 1990-1993. Poorest survival was 3.6% in 1991. Average annual survival of bulls $\geq$ 2 years old during 1984-1992 was 17.2%.

One of the 1993 cohort of bulls $\geq$ 2 years old was shot in HD300, and six spent a substantial time during the hunting season in Idaho. One original member of this cohort (not included in the sample) which had moved to the Gallatin drainage as a yearling was shot there as a 2 year old. An Idaho bull that had wintered on the BTWMA as a yearling moved back to Idaho and was shot there as a 2 year old.

Crippling loss (seven males) has averaged 6.6% of retrieved legal kill (106 males) for radio-transmitter collared bulls. There were no archery kills of radio-transmitter collared bulls during 1993.

Table 7. Mortality rates of adult female elk ($\geq$ 1 year) based on a sample with functioning radio-transmitter collars.

Time	N	Total Deaths	Shot	Crippling Loss	Shot - Not Reported	Natural[a]	Unknown	Total Hunting Related
1 June 1984 - 31 May 1985	26	2 (7.7)[b]	1	0	0	1	0	1 (3.9)[b]
1 June 1985 - 31 May 1986	52	4 (7.7)	2	1	1	0	0	4 (7.7)
1 June 1986 - 31 May 1987	59	3 (5.1)	2	0	0	1	0	2 (3.4)
1 June 1987 - 31 May 1988	64	11 (17.2)	11	0	0	0	0	11 (17.2)
1 June 1988 - 31 May 1989	64	11 (17.2)	10[c]	0	1	0	0	11 (17.2)
1 June 1989 - 31 May 1990	79	13 (16.5)	9	1	1	1	1	11 (13.9)
1 June 1990 - 31 May 1991	71	11 (15.5)	5	3	1	1	1	9 (12.7)
1 June 1991 - 31 May 1992	57	13 (22.8)	10	1	1	0	1	12 (21.1)
1 June 1992 - 31 May 1993	56	7 (12.5)	5	2	0	0	0	7 (12.5)
1 June 1993 - 31 May 1994	61	6 (9.8)	5	1	0	0	0	6 (9.8)
Total	589	81 (13.8)	60 (74.1)[d]	9 (11.1)[d]	5 (6.2)[d]	4 (4.9)[d]	3 (3.7)[d]	74 (91.4)[d]

[a] Natural loss includes old age, malnutrition, disease, calving problems, predation, etc.

[b] Number (%) of annual sample

[c] Includes one archery-kill

[d] Number (%) of total deaths

Calves

One recently captured male calf died during spring 1994. This calf had injured his right eye and was blind in that eye prior to capture and marking. He died during April or early May and had been fed on by coyotes. The marrow fat indicated good physical condition, and the status of the remains were similar to those of a predator kill rather than a scavenged animal. Cause of death is not certain, but this calf with the blind eye was undoubtably more vulnerable to predation than most calves. All other radio-transmitter collared calves survived through the report period except one for which the fate was unknown because the transmitter never functioned after marking.

Harvest Surveys and Check Stations

Total harvest of bulls $\geq$ two years old continued to decline from the high in 1991 but remained higher than levels of the 1970s and early 1980s (Fig. 5). Total bull harvest declined to average levels of the mid 1970s through 1990. Reported yearling bull harvest (illegal) was at a very low level. The number of hunters was at the highest level observed during 1971-1993 (Fig. 5). This was mostly related to 1,120 more antlerless permits issued in 1993 than 1992.

Total antlerless harvest was near the record levels of 1991 and 1992, but hunter success was the lowest recorded since 1968 (Table 8). Although antlerless permits were increased by 46%, poor hunting conditions resulted in an antlerless harvest 11% below that of 1992. Check station data (Table 9) indicated a 25% decline in antlerless harvest from 1992 to 1993 but almost no change in bull harvest.

Abandoned elk, crippling loss, and/or illegal kill reported at check stations (Table 10) was lower for spike bulls and higher for legal bulls, adult females, and calves than in 1992.

Antler Characteristics

Hamlin and Ross (1992) discussed antler characteristics of yearling bulls in southwestern Montana, genetic and nutritional considerations, and presented preliminary information in a test of a hypothesis that increasing survival of larger, branch-antlered yearlings would result in larger antlered older bulls. Some information further updating this hypothesis testing is presented in Table 11. Thus far, two-year old bulls produced under the BTB regulation have not produced larger antlers than those produced under the BAB regulation (Table 11). Pre-treatment data (BAB regulation) for known or incisor cementum-aged three-year-old bulls indicated an average of 5.24 points/side (N=71 antlers, 36 individuals) and an average main beam length of 854.5 mm (N=66 antlers, 34 individuals). Two years of data for the treatment (BTB regulation) indicated an average of 5.33 points/side (N=21 antlers, 11 individuals) and an average main beam length of 879.0 mm (N=19 antlers, 10 individuals) for three-year old bulls. For the

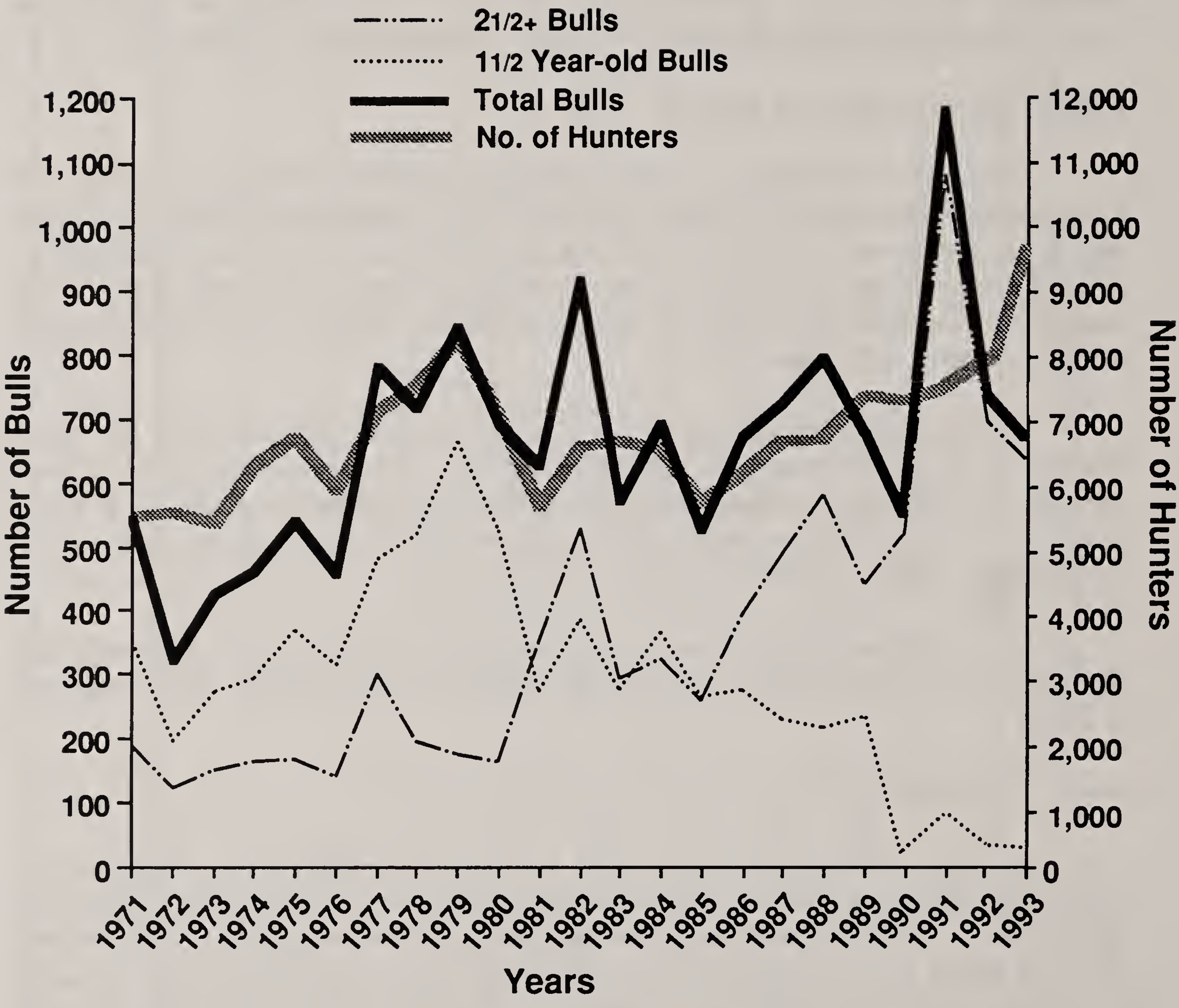


Figure 5. Numbers of hunters and harvest of total bulls, yearling bulls, and bulls ≥ 2 years old in Gravelly-Snowcrest hunting districts as estimated by statewide hunter harvest survey, 1971-1993.

Table 8. Antlerless harvest in HDs 322, 323, 324, 325, 326, 327, and 330 based on the statewide hunter harvest survey.

Year	No. of Permits	Cows Harvested	Calves Harvested	Total Harvested	Percent Success
1967	125	156	14	170	--
1968	470	290	48	338	72
1969	700	336	71	407	58
1970	735	280	33	313	43
1971	674	192	27	219	32
1972	672	189	60	249	37
1973	475	171	34	205	43
1974	300	92	17	109	36
1975	300	134	18	152	51
1976	350	138	25	163	47
1977	350	184	28	212	61
1978	716	302	39	341	48
1979	576	243	43	286	50
1980	425	195	18	213	50
1981	325	149	20	169	52
1982	725	396	29	425	59
1983	1,275	596	74	670	53
1984	1,775	719	96	815	46
1985	1,950	709	122	831	43
1986	1,500	500	89	589	39
1987	1,500	606	67	673	45
1988	1,750	771	98	869	50
1989	1,950	721	123	844	43
1990	2,000	633	79	712	36
1991	2,000	963	168	1,131	57
1992	2,420	976	132	1,108	46
1993	3,540	893	107	1,000	28

Table 9. Season-long results from hunter check stations operated in the Gravelly-Snowcrest Mountains during 1984-1992.

Check Station[a]	Year	No. Hunters	Elk				Mule Deer			White-tailed Deer		
			Males		Females	Calves	Males	Females	Fawns	Males	Females	Fawns
			Yrlng.	2+								
All	1984	3,425	16	40	97	25	154	106	51	26	6	3
	1985	3,124	12	72	110	31	214	121	29	23	5	3
	1986	6,231	33	89	99	30	309	155	46	63	19	22
	1987	5,075	31	93	135	33	376	135	32	49	14	15
	1988	4,944	36	95	178	39	450	112	28	46	19	18
	1989	5,001	26	97	136	58	328	98	20	50	8	13
	1990	4,508	2[b]	81	119	30	312	138	34	31	7	3
	1991[c]	4,087	1	151	174	61	316	162	23	38	20	8
	1992	4,861	1	118	183	53	297	183	33	48	21	9
	1993	4,965	0	120	136	40	145	187	52	33	22	14
Ruby	1984	1,698	11	23	57	11	127	100	43	20	6	3
	1985	1,623	10	46	82	27	161	105	27	19	5	3
	1986	2,172	11	42	47	14	146	93	30	33	9	18
	1987	2,135	14	36	69	18	175	83	18	26	4	7
	1988	2,096	14	39	62	19	204	62	15	17	6	9
	1989	1,832	4	28	55	27	147	43	9	19	1	3
	1990	1,830	0	34	43	15	167	56	17	17	5	1
	1991	1,522	0	50	51	21	158	74	9	9	1	3
	1992	1,738	0	47	77	23	125	69	10	18	3	6
	1993	2,019	0	56	62	19	52	63	14	10	4	4
Blacktail Road	1986	1,882	11	20	28	9	102	39	5	24	10	4
	1987	1,930	11	29	38	7	135	38	10	18	10	7
	1988	1,831	11	25	53	3	136	38	9	21	11	7
	1989	2,256	14	40	48	23	137	42	11	26	4	9
	1990	1,781	1[b]	22	34	9	99	66	11	13	2	1
	1991	1,887	1	60	77	21	105	74	9	9	1	3
	1992	2,214	1[b]	40	64	18	118	93	19	29	13	3
	1993	2,045	0	28	37	14	63	101	30	19	14	9
Ennis	1986	2,177	11	27	24	7	61	23	11	6	0	0
	1987	1,010	6	28	28	8	66	14	4	5	0	1
	1988	1,017	11	31	63	17	110	12	4	8	2	2
	1989	913	8	29	33	8	53	13	0	5	3	1
	1990	897	1[b]	27	42	6	46	16	6	1	0	1
	1991[c]	678	0	41	46	19	53	21	5	7	2	-
	1992	909	0	31	42	12	54	21	4	1	5	0
	1993	901	0	36	37	7	30	23	8	4	4	1

[a] The Upper Ruby Creek Check Station was the only one operated each year 1984-1989. In 1984 and 1985, 2-3 other stations were manned on the east side of the Gravellys. In 1986, those were combined into one station at Ennis and a new station was opened on the Blacktail Road south of Dillon.

[b] Illegal kill.

[c] Ennis check station not operated opening day in 1991.

Table 10. Crippling loss, abandoned elk, and/or illegal kill reported at check stations.

Year	Spikes	Legal Bulls	Adult Females	Calves
1988	82	6	27	5
1989	41	2	36	3
1990	28	4	38	3
1991	18	2	19	1
1992	26	2	11	1
1993	21	8	15	6

Table 11. Number of points per side and main beam length of 2½ year old bulls harvested in the Gravelly-Snowcrest Mountains, 1984-1993. Beam length displayed in millimeters.

		1984	1985	1986	1987	1988	1989	1990	1984-1990 Mean	1991	1992	1993
Points/Side	N	54 (27)[a]	82 (41)	126 (65)	152 (76)	136 (68)	148 (74)	120 (60)		184 (92)	195 (98)	189 (97)
	$\bar{X}$	4.37	4.52	4.76	4.58	4.65	4.53	4.38	4.54	4.49	4.47	4.38
Main Beam Length	N	53 (27)	80 (41)	126 (64)	144 (74)	125 (66)	143 (66)	118 (59)		176 (92)	185 (96)	184 (96)
	$\bar{X}$	731.7	751.5	765.0	765.2	762.1	745.6	755.6	753.8	730.5	780.7	717.9
Only the 25% largest each year												
Points/Side	N	7	10	16	19	17	18	15		23	25	24
	$\bar{X}$	5.00	5.05	5.38	5.18	5.15	5.36	5.13	5.18	5.11	5.16	5.08
Main Beam Length	N	7	10	16	18	16	18	15		22	23	24
	$\bar{X}$	838.7	881.8	889.1	885.2	877.1	877.7	862.1	873.1	850.3	869.8	823.4
Only the 25% smallest each year												
Points/Side	N	7	10	16	19	17	18	15		23	25	24
	$\bar{X}$	3.79	3.60	3.97	3.71	3.97	3.53	3.40	3.71	3.74	3.53	3.69
Main Beam Length	N	7	10	16	18	16	18	15		22	23	24
	$\bar{X}$	591.9	608.9	634.7	630.9	608.4	612.6	620.5	615.4	608.8	681.7	609.0

[a] Number of antlers (number of individuals); because of broken or deformed antlers, number of antlers is not always twice the number of individuals.

small sample thus far, three-year old bulls produced under the BTB regulation have had slightly larger antlers than those produced under the BAB regulation.

The first four-year-old bulls produced under the BTB regulation were measured in autumn 1993. This treatment sample includes only two bulls thus far. Pre-treatment data for four-year-old bulls was an average of 5.90 points/side (N=21 antlers, 11 individuals) and an average main beam length of 1028.3 mm (N=20 antlers, 11 individuals). Pre-treatment data for five-year old bulls was an average of 6.10 points/side (N=10 antlers, 5 individuals) and an average main beam length of 1127.0 mm (N=5 antlers, 3 individuals).

Herd Ranges and Movements

Herd Ranges

Herd ranges, as determined by female elk, are presented for eight population segments (herds) in Figures 6-11. Locations presented in these Figures includes females that shifted winter ranges, but remained within the Gravelly-Snowcrest complex.

Herd range (2,446 mi.^{2}) for female elk captured and marked on the WCWMA (Fig. 6) is based on 3,412 locations of 281 marked females during March 1984 through 30 June 1994. These locations indicate that a majority of WCWMA elk confine their movements to HD 323. Other areas receiving considerable use include the West Fork of the Madison River, the Horn Mountains, areas northwest of West Yellowstone and south of Quake Lake, and the west slope of the Gravelly Mountains. There is some interchange with Cherry-Morgan elk.

Most locations of 188 female elk captured and marked on the BTWMA are within HD 324 (Fig. 7). Herd range is 2,722 mi.^{2} based on 2,373 locations made from March 1986 through 30 June 1994. Substantial numbers of elk use the upper West Fork of the Madison River, Coal, Long, and Fish Creek areas along with the Centennial Mountains from Jones Creek to Hellroaring Creek. There is some interchange with Robb-Ledford elk.

Herd range (1,608 mi.^{2}) for female elk captured and marked on the Cherry-Morgan winter range is based on 301 locations of 37 marked females from February 1985 through 30 June 1994 (Fig. 8). Although most of these elk use HD 330, substantial numbers use HD 323 and HD 324.

For eleven female elk captured and marked on the Basin-Sage Creek winter range (Fig. 9), herd range was 799 mi.^{2} based on 270 locations from March 1989 through 30 June 1994. These elk spend most of spring, summer, and autumn in the Centennial Mountains in the Monida to Jones Creek area of Montana and Camas Creek area of Idaho.

Herd ranges for 28 female elk captured and marked on the Robb-Ledford winter range and 3 female elk captured and marked on the Axolotl winter range are presented in

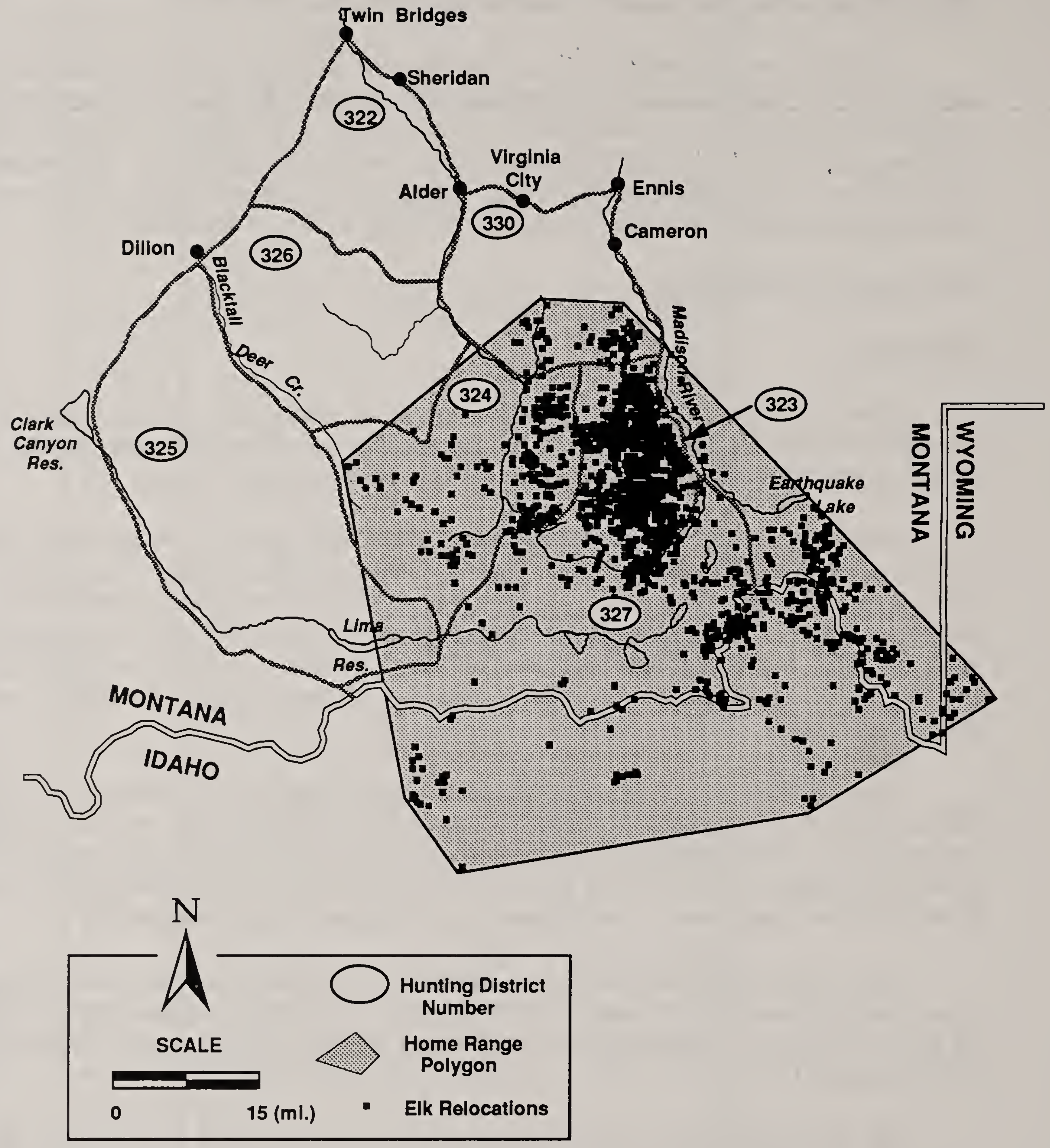


Figure 6. Herd range for 281 female elk captured and marked on the Wall Creek Wildlife Management Area, March 1984 through 30 June 1994.

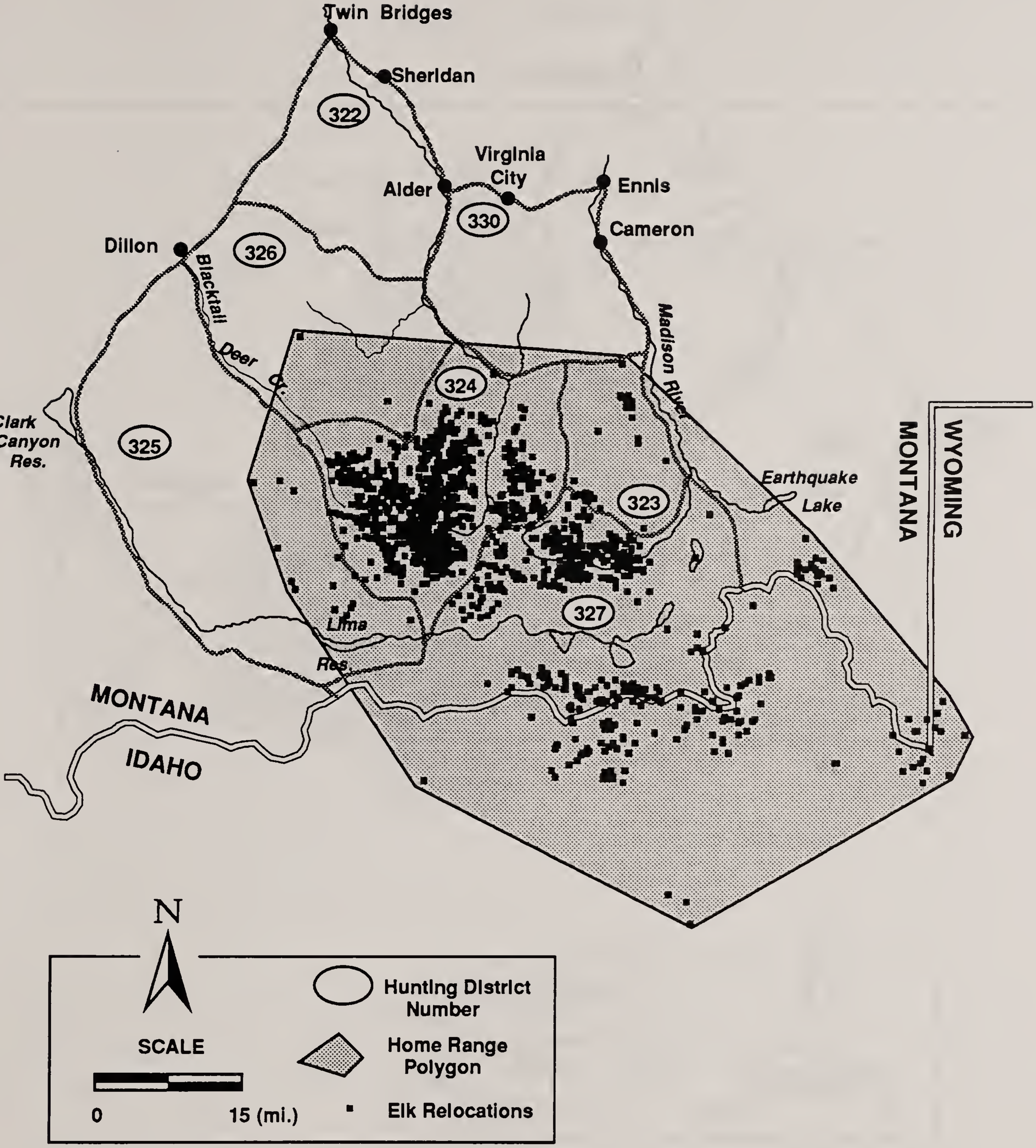


Figure 7. Herd range for 188 female elk captured and marked on the Blacktail Wildlife Management Area, March 1986 through 30 June 1994.

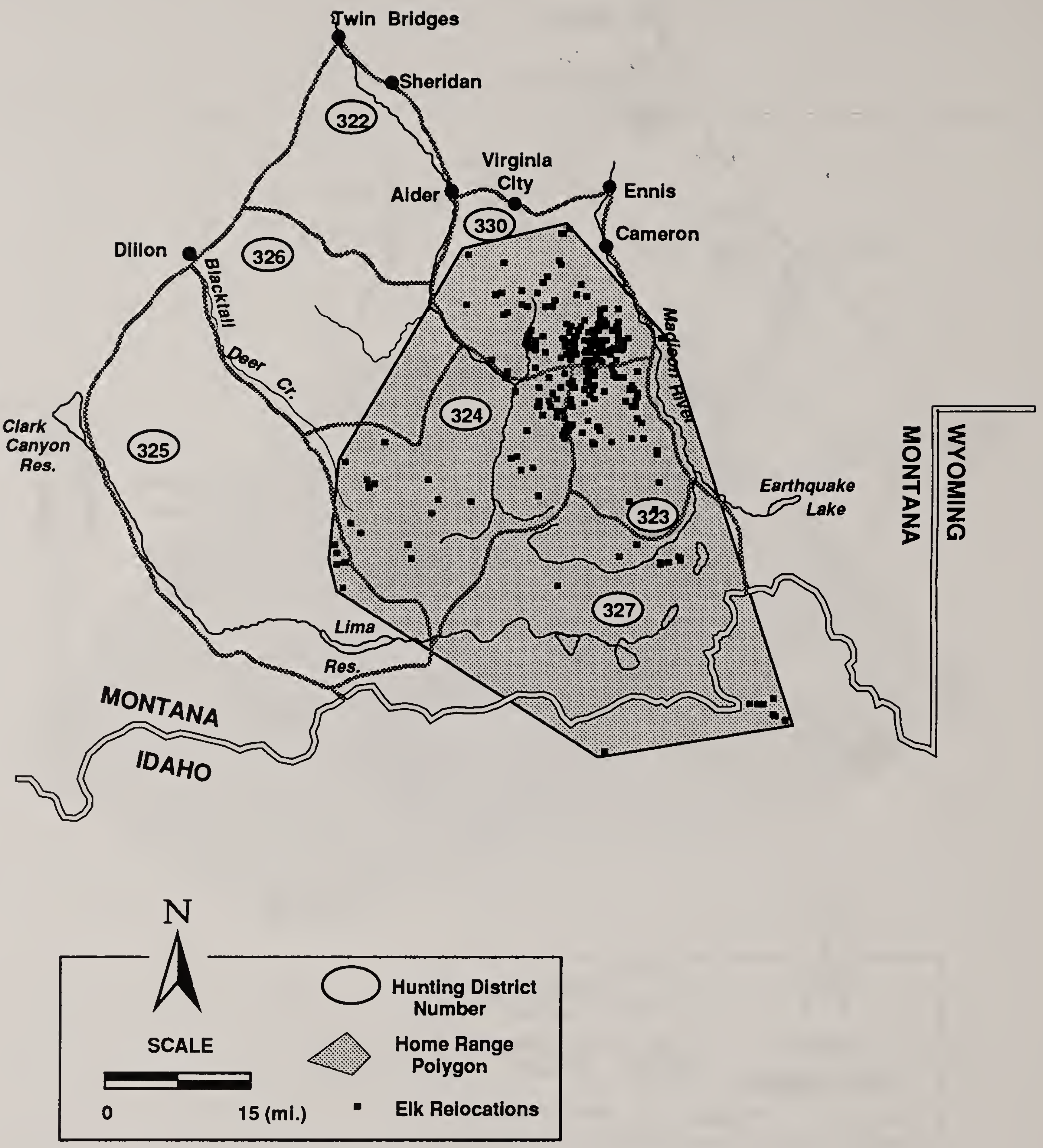


Figure 8. Herd range for 37 female elk captured and marked on the Cherry-Morgan winter range, February 1985 through 30 June 1994.

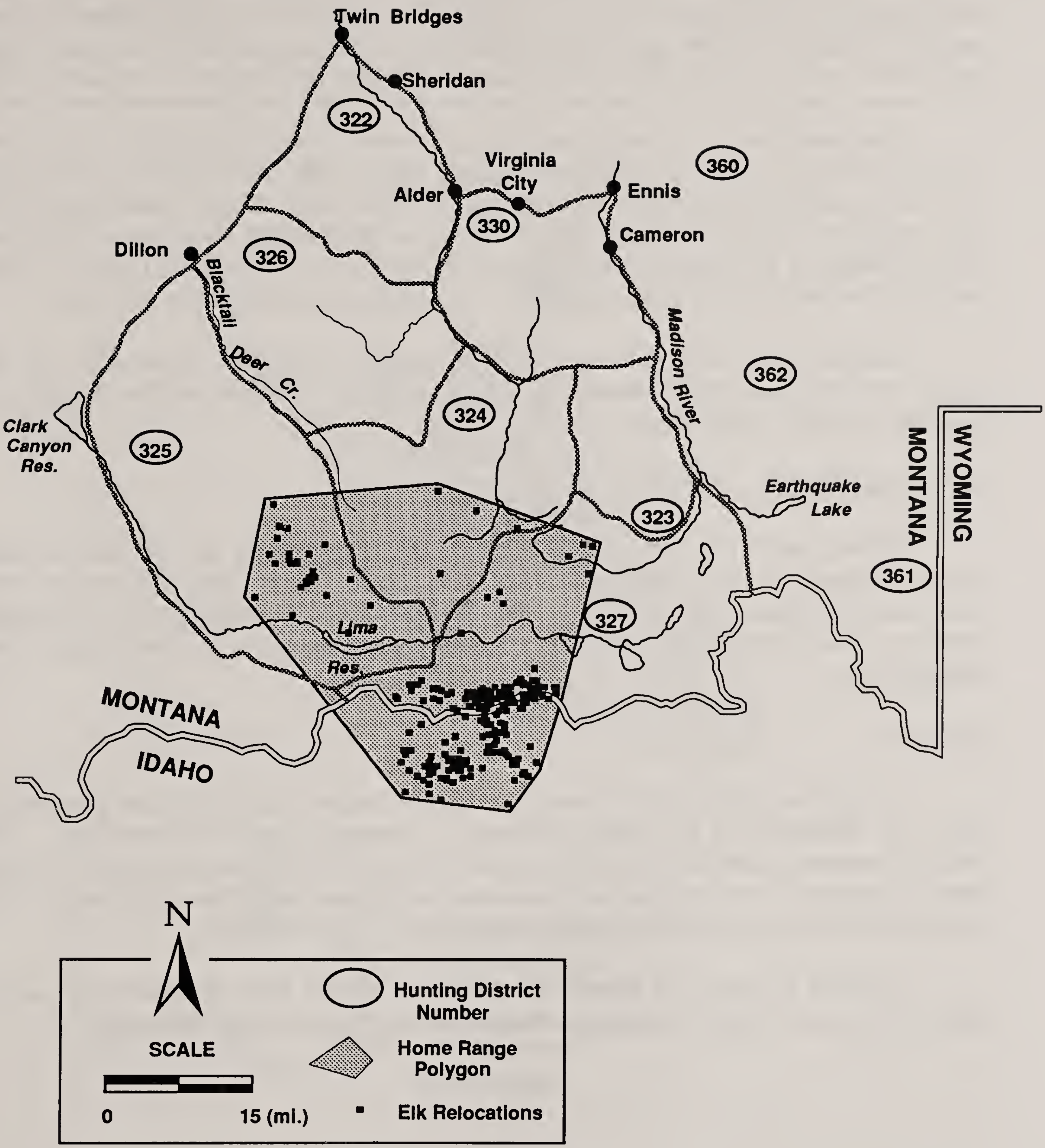


Figure 9. Herd range for 11 female elk captured and marked on the Basin-Sage Creek winter range, March 1989 through 30 June 1994.

Figure 10. Herd range for Robb-Ledford females was 1,015 mi.^{2} based on 577 locations and herd range for Axolotl females was 30 mi.^{2} based on 40 locations. Robb-Ledford elk were mainly confined to the northwest portion of the Snowcrest Range as well as the entire upper Ruby River valley. Axolotl elk primarily spent seasons other than winter in Wigwam Creek.

Herd range for 11 female elk captured and marked on the Warmsprings Creek winter range was 290 mi.^{2} based on 317 locations from March 1989 through 30 June 1994 (Fig. 11). Most locations were within the Main, Middle, and South Forks of Warmsprings Creek. Herd range for 6 female elk captured and marked on the Blacktail Ridge winter range was 248 mi.^{2} based on 43 locations from December 1992 through 30 June 1994 (Fig. 11). Most stayed within the Blacktail Ridge area, but one used the upper Blacktail Creek area.

Females from two other wintering areas, the Greenhorn Mountains and the Sweetwater Hills were first captured and marked in spring 1994 and too few locations are available to present herd ranges.

Calving Locations

Calving locations (Fig. 12) were based on 610 locations of 221 radio-collared females, 3-years or older, made between 20 May and 20 June during 1984 through 1994. These locations indicate that calving is well dispersed throughout the Gravelly-Snowcrest complex. Some clumping occurs, but this is partially accentuated by unequal samples from different areas.

Dispersal

Long distance dispersal of male (Fig. 13) and female (Fig. 14) elk are presented if they were considered to have made permanent movements outside the study area. The furthest movement recorded thus far for a male was about 250 airline miles east to near Ten Sleep, Wyoming. Other dispersals include to near Jackson Hole, Wyoming, Idaho's Sand Creek winter range, the Madison Range, and Tobacco Root Mountains.

Dispersal of female elk include movements to Jackson Hole, the Grand Tetons, the Sand Creek winter range, the Madison Range, and the Tobacco Root Mountains.

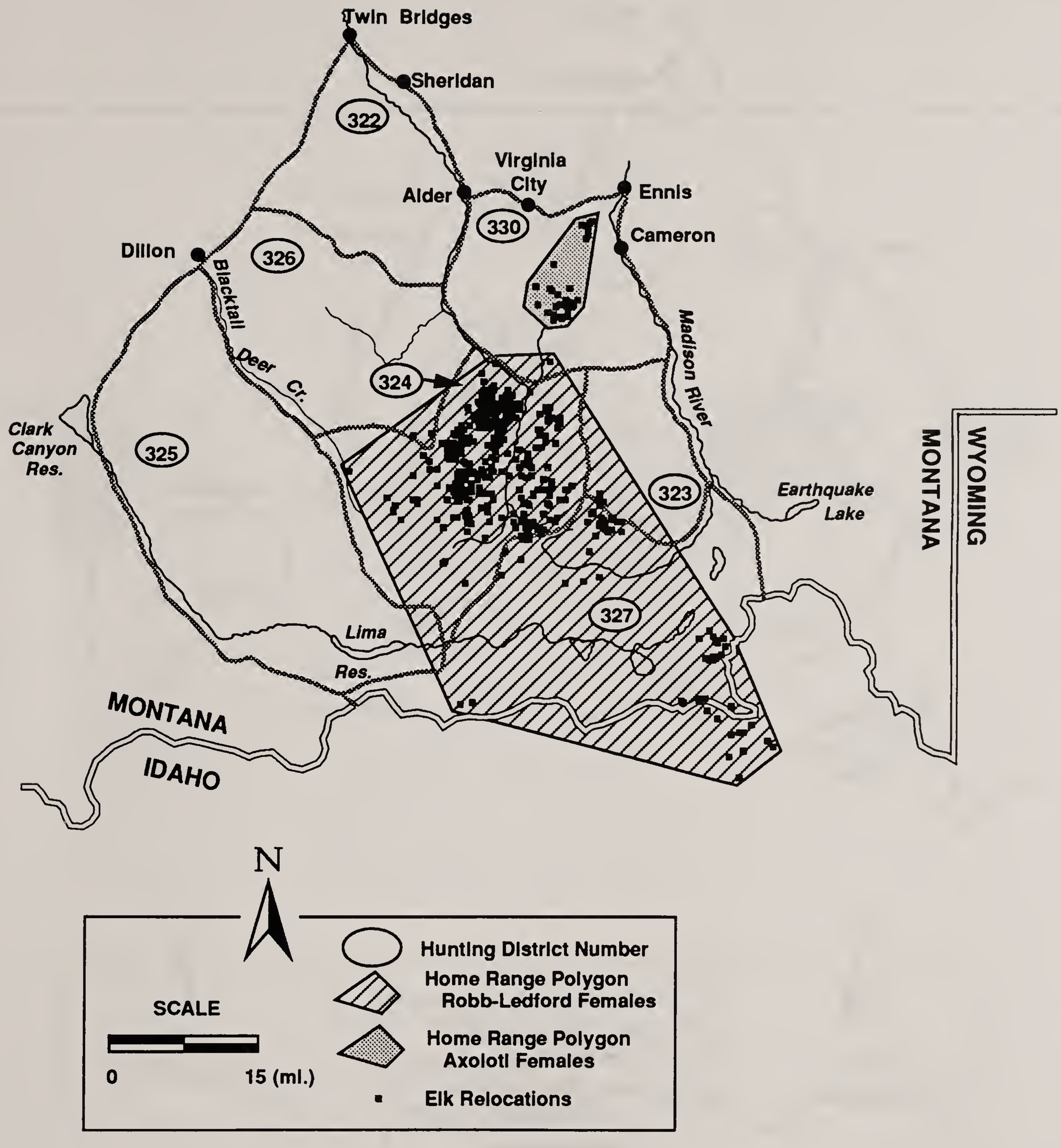


Figure 10. Herd ranges for 28 female elk captured and marked on the Robb-Ledford winter range March 1989 through 30 June 1994 and 3 female elk captured and marked on the Axolotl winter range March 1993 through 30 June 1994.

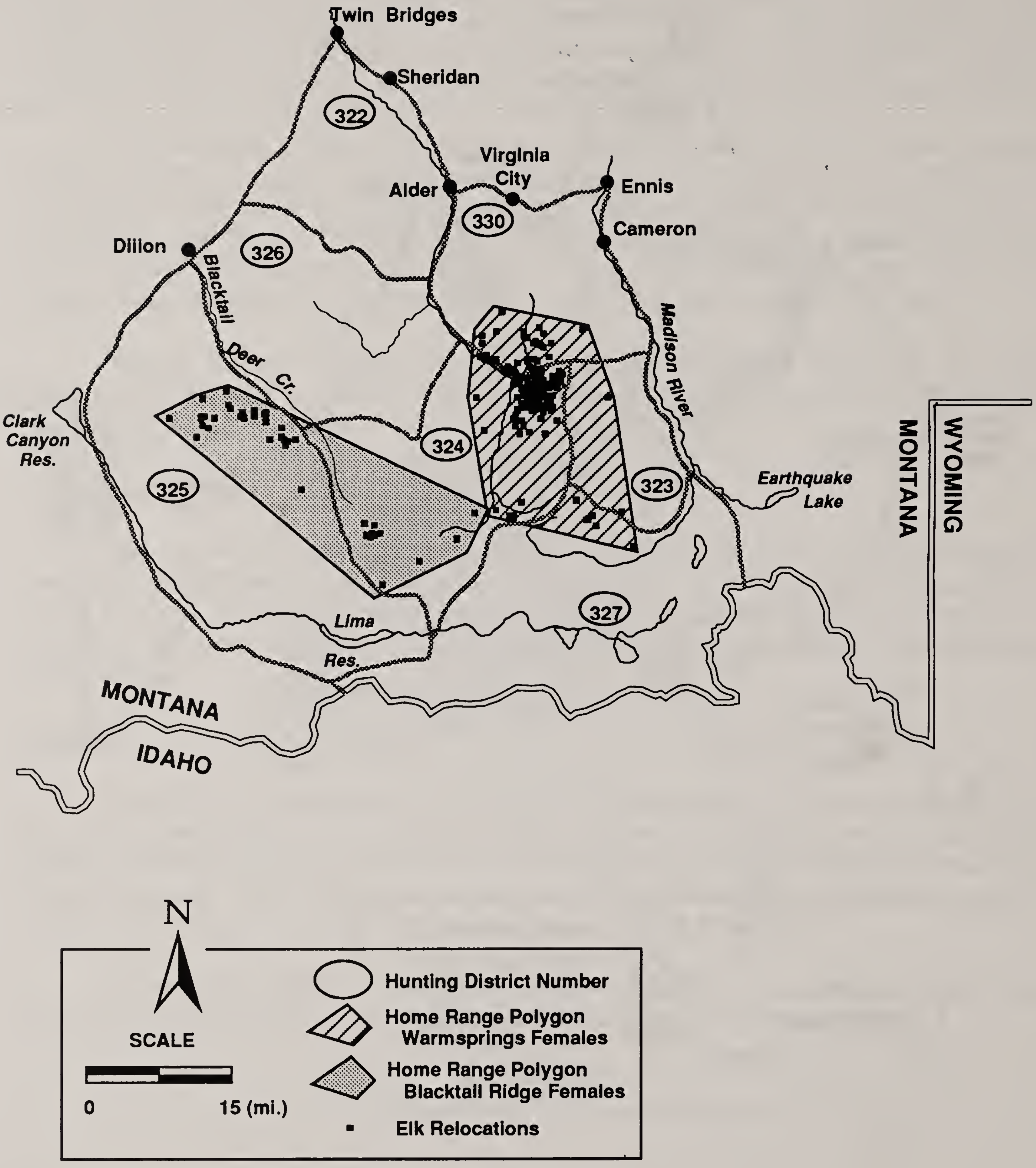


Figure 11. Herd ranges for 11 female elk captured and marked on the Warmsprings Creek winter range March 1989 through 30 June 1994 and 6 female elk captured and marked on the Blacktail Ridge winter range December 1992 through 30 June 1994.

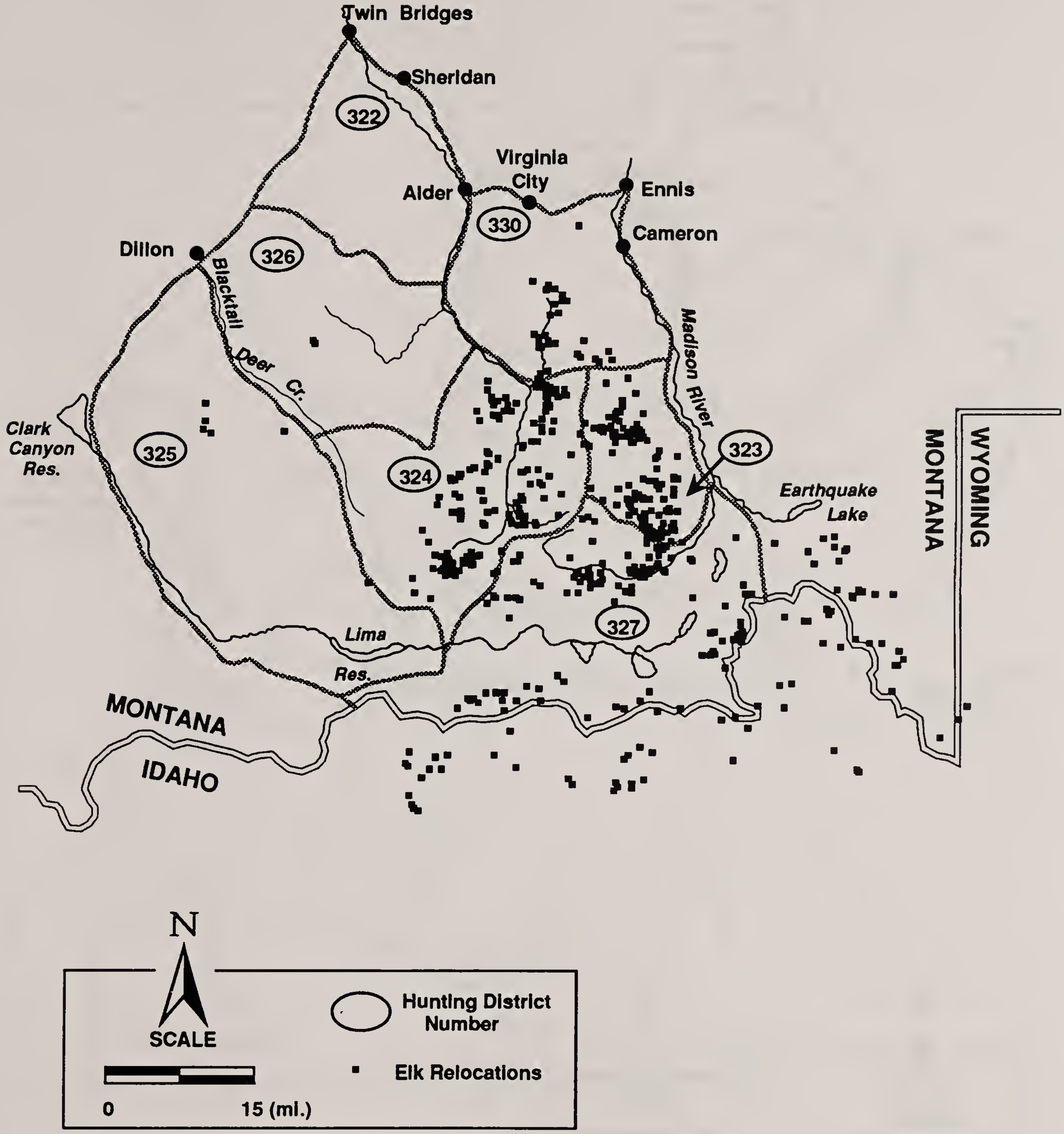


Figure 12. Calving locations of 221 radio-collared female elk, 3-years or older, based on 610 locations during 20 May through 20 June, 1984-1994.

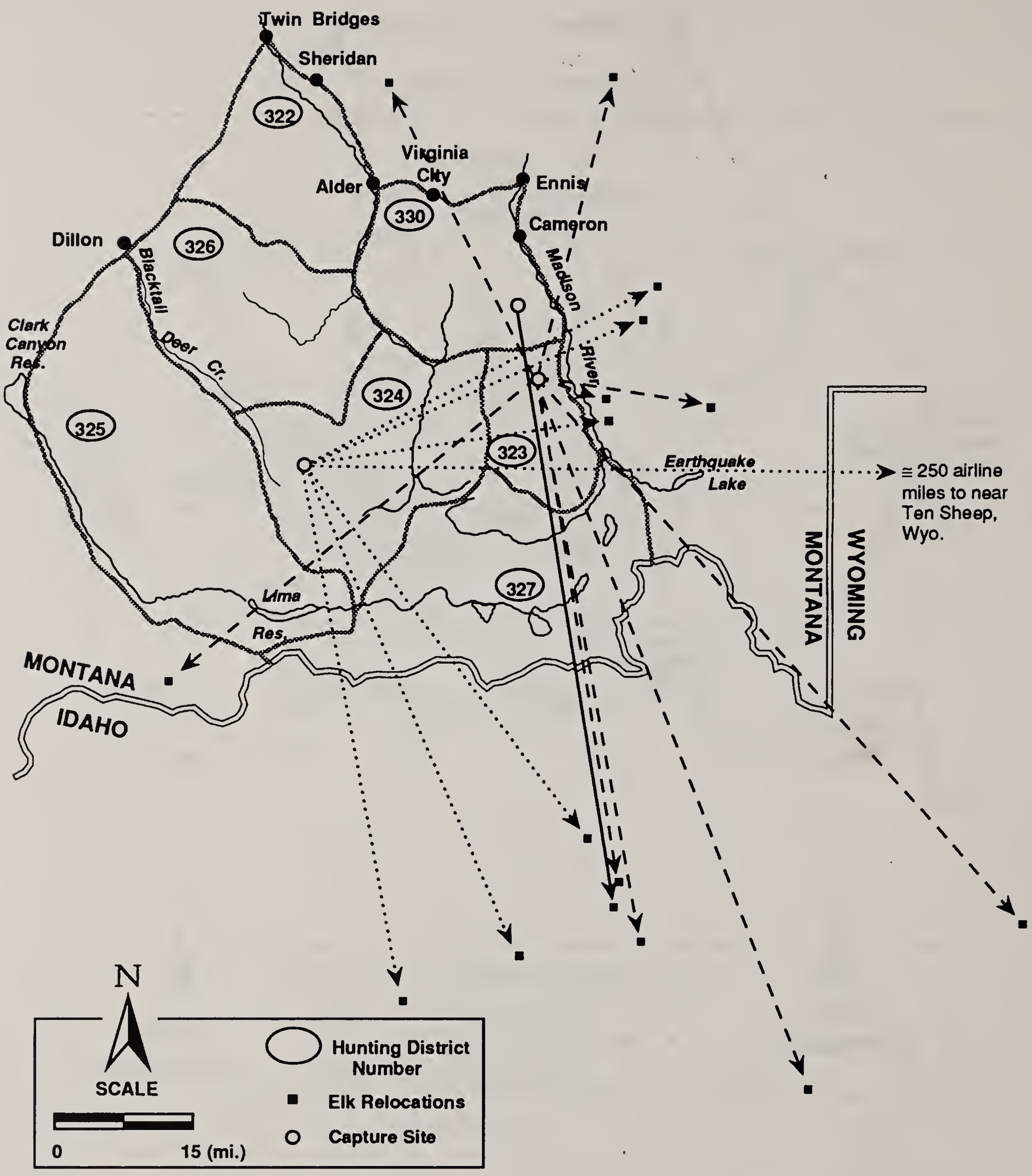


Figure 13. Long distance dispersal movements of male elk from the Gravelly-Snowcrest Mountains to areas outside study area boundaries.

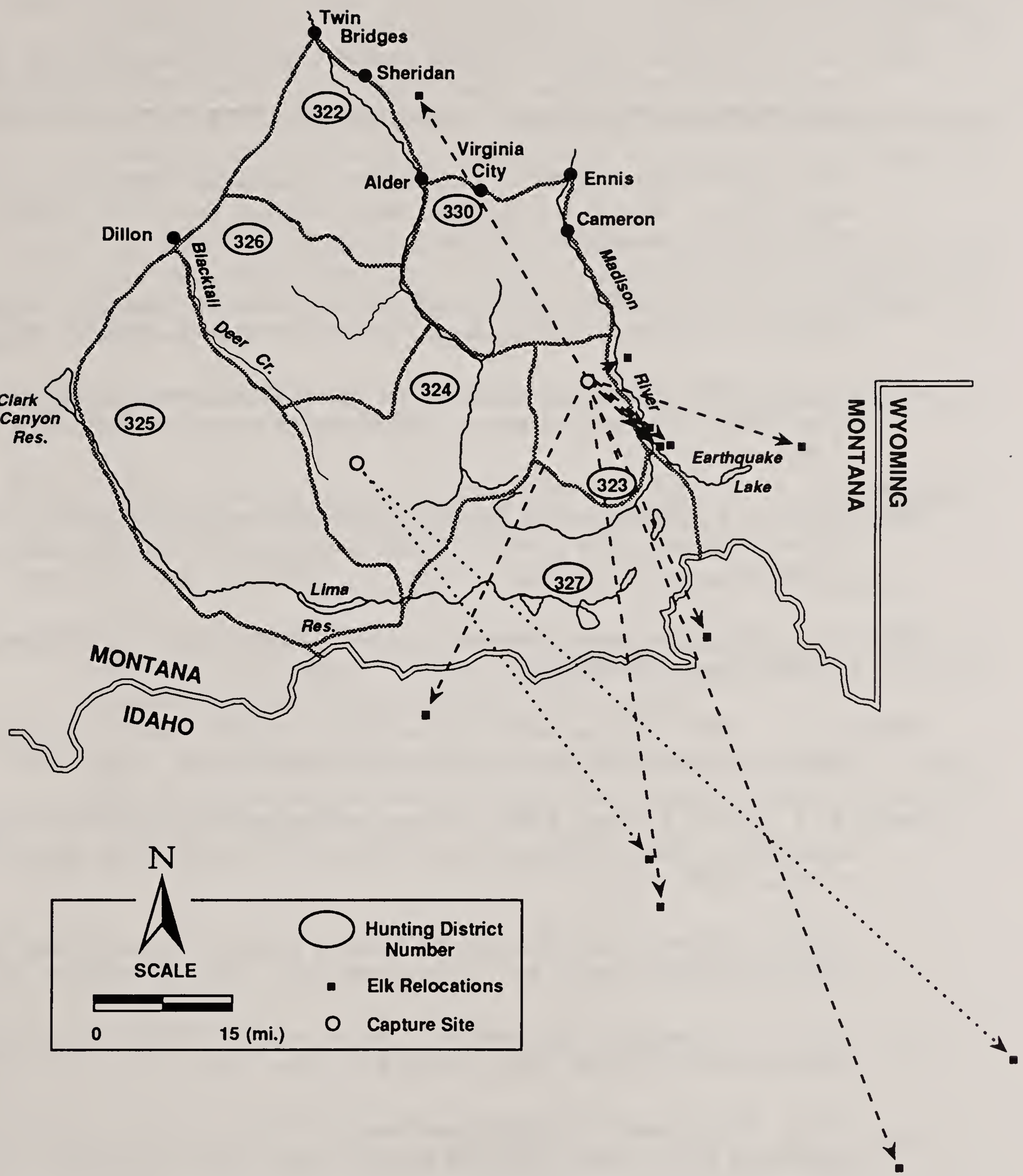


Figure 14. Long distance dispersal movements of female elk from the Gravelly-Snowcrest Mountains to areas outside study area boundaries.

LITERATURE CITED

Chrest, H., and J. Herbert. 1980. Statewide wildlife survey and inventory in Big Game Survey and Inventory, Region Three. Unpubl. P-R Job Prog. Rept., Montana Dept. Fish, Wildlife and Parks, Helena. Montana Proj. W-130-R-11, Job I-3. 118 pp.

_____. 1981. Statewide wildlife survey and inventory in Big Game Survey and Inventory, Region Three. Unpubl. P-R Job Prog. Rept., Montana Dept. Fish, Wildlife and Parks, Helena. Montana Proj. W-130-R-12, Job I-3. 105 pp.

DeSimone, R. M., and J. Vore. 1992. Elkhorn Mountains elk monitoring program. Unpubl. P-R Job Rept., Montana Dept. Fish, Wildl. and Parks, Helena. 110 pp.

Eustace, C. D. 1967. Food habits, range use and relationships between elk and livestock in the Gravelly Mountains, Montana. MS Thesis, Montana State Univ., Bozeman. 55 pp.

French, C. E., L. C. McEwen, N.D. Magruder, R. H. Ingram, and R. W. Swift. 1956. Nutrient requirements for growth and antler development in the white-tailed deer. J. Wildl. Manage. 20:221-232.

Gilbert, F. F. 1966. Aging white-tailed deer by annuli in the cementum of the first incisor. J. Wildl. Manage. 30:200-202.

Gniadek, S. J. 1987. Elk and cattle relationships on summer range in southwestern Montana. Unpubl. M.S. Thesis, Univ. of Montana, Missoula. 63 pp.

Hamlin, K. L., and M. S. Ross. 1990a. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-19/20. 27 pp.

_____. 1990b. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-21. 77 pp.

_____. 1991. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-22. 29 pp.

_____. 1992. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-23. 27 pp.

_____. 1993. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-100-R-1. 24 pp.

Hines, W. W., and J. C. Lemos. 1979. Reproductive performance by two age-classes of male Roosevelt elk in southwestern Oregon. Ore. Dept. of Fish and Wildl. Res. Rept. No. 8. 54 pp.

Lonner, T. N., and P. Schladweiler. 1987. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job. Prog. Rept., Proj. W-120-R-18. 26 pp.

Prothero, W. L., J. J. Spillett, and D. F. Ralph. 1979. Rutting behavior of yearling and mature elk: some implications for open bull hunting. Pages 160-165 in Boyce, M. S., and L. D. Hayden-Wing, eds., North American Elk: Ecology, Behavior and Management. Univ. of Wyoming, Laramie. 294 pp.

Quimby, D. C., and J. E. Gaab. 1957. Mandibular dentition as an age indicator in Rocky Mountain elk. J. Wildl. Manage. 21:435-451.

Smith, J. 1980. Managing elk in the Olympic Mountains. Pages 67-111 in W. Macgregor, ed., Proc. West. States Elk Workshop, Cranbrook, B.C., Feb. 27-28, 1980.

Wildlife Division: MDFWP. 1967-1992. Annual elk hunting and harvest reports.

Wildlife Division: MDFWP. 1985. Antlered elk and deer management in Montana: past trends and current status. A special report for the Fish and Game Commission, Montana Dept. Fish, Wildl. and Parks, Helena. 68 pp.

Wood, A. K., R. E. Short, A. Darling, G. L. Dusek, R. G. Sasser, and C. A. Ruder. 1986. Serum assays for detecting pregnancy in mule and white-tailed deer. J. Wildl. Manage. 50: 684-687.